Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Engineering 18 (2011) 1 – 6
Procedia Engineering
www.elsevier.com/locate/procedia

The Second SREE Conference on Chemical Engineering

A Modified Ring Spinning System with Various Diagonal Yarn Path Offsets

Tingting Wu[a,b]*, Chunping Xie[a,b], Xuzhong Su[a,b], Xinjin Liu[a,b], Bin Huang[a,b]

[a] *Key Laboratory of Eco-Textile Ministry of Education, Jiangnan University, Wuxi 214122, P. R. China*
[b] *School of Textile and Clothing, Jiangnan University, Wuxi 214122, P. R. China*

Abstract

A modified ring spinning system was proposed to make various diagonal yarn paths and offsets by equipping a traverse guide between delivery roller nip and lappet guide while the yarn leaving the front roller nip threaded through the traverse guide and went to bobbin below. Test properties of yarn counts 20^s, 40^s, 60^s (100% cotton), spun on the modified yarn path system under various right & left diagonal offset d = 0, 6, 12, 18mm. with a high speed camera, photographs of spinning triangle in different diagonal paths were captured and studied. The results suggested this modification system could improve yarn hairiness without changing tensile and unevenness properties greatly in right diagonal path. The maximum reduction of 3-9mm long hairiness from Ne 20, Ne 40 to Ne 60 was 42.6%, 28.5% and 21.3%. The coarser yarns received more significant improvement on hairiness. It is observed that diagonal path is the most important factor to decide yarn hairiness over all counts of yarns.

Keywords: spinning triangle, diagonal path, diagonal offsets, yarn hairiness;

1. Introduction

In ring spinning process, the drafted strand leaves the front roller nip and is twisted into a yarn. This twist region between the front roller nip and the fibre convergence point is called the spinning triangle or twisting triangle. It is a critical region where paralleled fibres get twisted and merged to form a yarn structure. The compact ring spinning, through minimizing or even eliminating the spinning triangle, significantly reduces yarn hairiness. Therefore the study on spinning triangle is a key for ring spinning modification.

Over the past decades, various studies of spinning triangle have been carried out. Fujino et al. [1] studied twist irregularity of cotton and worsted spun yarns on a ring spinning frame with a theoretical consideration of force balances in the spinning triangle. The study showed that the height of the spinning triangle depends on the spinning tension, the fibre distribution at the roller nip, the fibre tensile elastic modulus and the width of the spinning triangle. In the investigation of fibre strand force within spinning

* Tingting Wu. Tel.: +86-510-85197922; fax: +86-510-85912009
E-mail address: wtt330327@163.com.

doi:10.1016/j.proeng.2011.11.001

triangle, Pavlov [2] studied structural transformations of the fibres at rupture. It showed fibre force within spinning triangle depends on the number of fibres contributing to the strength of fibre assembly, the roller pressure at roller nip, dominating fibre strength and friction coefficient of the fibres under drafting rollers. Klein [3] stated that the spinning triangle and spinning angle affect fibre breakage considerably, while the spinning triangle also influences yarn structure. Krause [4] investigated the strength of the spinning triangle for cotton spun yarns by considering different extensions of fibre at the spinning triangle.

Traditionally spinning triangle is often assumed to be symmetrical. However, in ring spinning practice the triangle is asymmetric. According to Najar's study [5], in a Z-twist yarn, fibres on the right side of the triangle often undergo a pre-twisting process which effectively binds the fibres, while the left side fibres are comparatively less controlled. These cause an asymmetric fibre distribution in spinning triangle, and the left side fibres are more likely to become hair fibres. The compact ring spinning systems reduce the spinning triangle or twist triangle to a minimum to ensure less yarn hairiness. A modified yarn path in which yarn delivered from a drafting unit is taken up by its adjacent bobbin to the left of the drafting unit instead of bobbin directly below the drafting unit was carried out by Wang and Chang in worsted ring spinning [6, 7]. The result showed that left diagonal yarn path produced lower hairiness than the conventional ring spun yarn due to the reduced distance that the left side fibres have to travel before reaching the convergence point in the spinning triangle. By using modified bottom roller, Thilagavathi's modified yarn path system could produce various left diagonal yarn path offsets in ring spinning [8]. This system was used to observe the influence of different left diagonal offsets on yarn properties. There is 40-75% hairiness reduction in S3 value at 60 mm left diagonal path offset compared to the straight path yarn. A modified ring spinning system was developed by Tao X M's group [9-10] with a false twisting device. A new spinning triangle was formed to produce a low torque and soft handle singles yarn. A theoretical mode of spinning triangle was also established by them.

In the methods of modified yarn path mentioned above, Wang was only able to modify the yarn path to adjacent bobbin; while Thilagavathi's method requested manufacturing new bottom rollers and adjusting the positions of pressure bar, pneumafil pipe, spacer and aprons. This method cost too much to produce various diagonal offsets and only considered left diagonal path circumstance. Thus in this paper, a new ring spinning modification system was proposed to make various diagonal offsets both on the right and left diagonal yarn path by equipping a traverse guide between delivery roller nip and lappet guide while the yarn leaving the front roller nip threaded through the traverse guide and went to bobbin below (as shown in Fig. 1.). Moving traverse guide on horizontal axis, various left and right diagonal offsets were made to form various spinning triangle geometries. With the help of a high speed camera, we were able to capture the images of spinning triangles under different diagonal yarn paths. Testing properties of yarn counts 20^s, 40^s, 60^s (100% cotton), spun on the modified yarn path system, each under right & left diagonal offset d = 0, 6, 12, 18mm. Based on the testing results and images of spinning triangle, we were able to find a best offset d where yarns had best performance, and compare the different twisting modes of left and right diagonal yarn path, eventually go to a primary explanation and description over spinning triangle with modified yarn path.

2. Experimental

2.1. Modified Ring Spinning System

Yarn counts of 20^s, 40^s, 60^s (100% cotton) was produced on the modified EJM128K ring spinning system. Each count of yarn had to go through both left and right diagonal path offsets d = 0, 6, 12, 18mm. The various offsets d was achieved by shifting the traverse guide on horizontal axis (as shown in Fig. 1.).

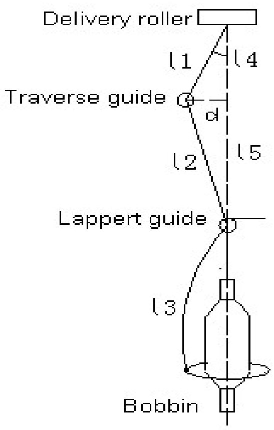

Fig.1. Modified Yarn Path System

2.2. Material and Spinning Parameters

Table1. Spinning parameters

Yarn count	Twist (tpm)	Total draft	Roving Quality
20^s	654.9	17.41	100% combed cotton, count 570 tex, micronaire value 4.5, fibre Length 28.1mm.
40^s	1024.3	38.74	
60^s	1382.9	46.28	100% combed cotton, count 445 tex, micronaire value 4.1, fibre Length 32mm.

2.3. Testing Methods

All yarn samples were tested under standard conditions. Yarn hairiness tested by YG172A hairiness tester was the most concerned property. This hairiness measurement gave 3-9mm hairiness amount in 10m yarn. Yarn tenacity and breaking elongation were obtained by YG063 tensile tester. The imperfection test was done on YG135G.

3. Results and Discussions

Table 2. - Table 4. showed the test results of yarn properties produced by the modified yarn path system. There is no significant change in unevenness as well as tensile properties of both left and right diagonal yarns. The test results of all counts of yarns show the diagonal path and offsets influence the yarn hairiness mostly.

3.1. The Effect of Diagonal Path on Hairiness

It is observed that diagonal path is the most important factor to decide yarn hairiness over all counts of yarns. The results of left and right diagonal yarns hairiness are quite different. Very few left diagonal yarn performs improvement of hairiness, while almost every right diagonal yarn reduces a great amount of 3-9mm long hairiness. There’s no significant change on yarn strength and evenness.

Table 2. Properties of Ne 20 yarns

Yarn type	3-9mm Hairiness (/10m)	Tenacity (cN/tex)	Tenacity CV (%)	Elongation (%)	Elongation CV (%)	Unevenness (CV_m%)	Thin -50% (/km)	Thick +50% (/km)	Neps +200% (/km)
0	121.1	18.0	5.0	7.3	4.5	9.89	0	0	0
R6	101.1	17.3	4.9	7.2	4.0	10.26	0	0	0
R12	69.5	17.8	4.2	7.4	3.2	10.15	0	0	0
R18	73.3	18.0	3.9	7.4	3.2	10.15	0	0	0
L6	127.5	16.9	4.6	7.1	4.1	9.37	0	0	0
L12	173.2	17.5	3.2	7.3	3.4	10.03	0	0	0
L18	171.0	17.4	3.4	7.2	4.1	10.17	0	0	0

Yarn type - *0* represents conventional yarns, *R* represents right diagonal, *L* represents left diagonal, *R6* represents right diagonal offset 6mm; *L6* represents left diagonal offset 6mm and so on.

Table 3. Properties of Ne 40 yarns

Yarn type	3-9mm Hairiness (/10m)	Tenacity (cN/tex)	Tenacity CV (%)	Elongation (%)	Elongation CV (%)	Unevenness (CV_m%)	Thin -50% (/km)	Thick +50% (/km)	Neps +200% (/km)
0	71.3	16.3	5.9	6.2	5.3	12.15	0	20	10
R6	54.8	16.6	5.9	6.0	5.4	12.62	20	50	30
R12	51.0	16.3	5.7	5.9	4.8	12.74	10	0	0
R18	57.1	15.2	6.3	5.8	5.4	12.92	0	10	10
L6	71.2	17.1	8.7	6.1	6.6	12.01	0	0	0
L12	86.6	16.4	8.9	5.7	7.8	12.29	0	20	0
L18	81.3	15.7	8.6	5.4	8.5	12.42	0	10	10

Table 4. Properties of Ne 60 yarns

Yarn type	3-9mm Hairiness (/10m)	Tenacity (cN/tex)	Tenacity CV (%)	Elongation (%)	Elongation CV (%)	Unevenness (CV_m%)	Thin -50% (/km)	Thick +50% (/km)	Neps +200% (/km)
0	62.8	16.4	5.8	5.9	5.9	14.53	30	70	30
R6	62.5	16.3	11.6	5.6	12.1	15.36	70	160	100
R12	49.4	14.9	11.9	5.2	14.3	14.83	30	90	80
R18	56.6	14.8	9.4	5.1	11.1	15.67	100	90	90
L6	111.2	15.7	11.4	5.4	13.6	15.18	40	110	110
L12	116.3	13.6	12.5	4.8	9.3	14.65	30	80	50
L18	101.5	14.6	12.8	4.9	13.8	14.71	30	60	80

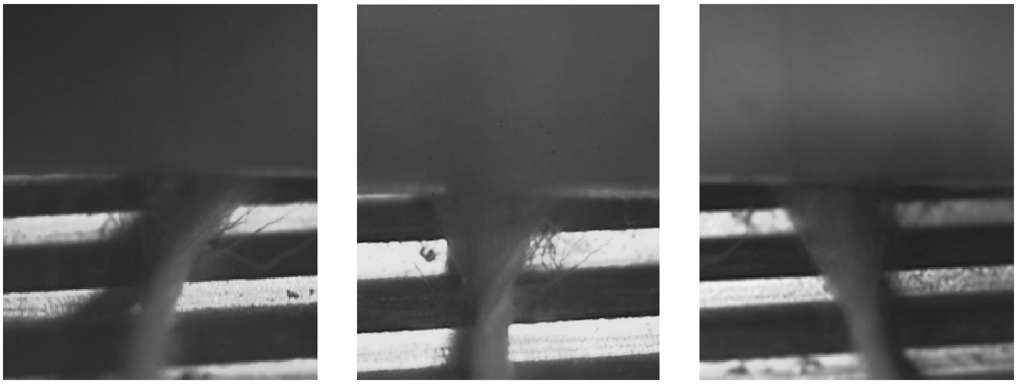

Fig. 2. (a) Left Diagonal; (b) Conventional Path; (c) Right Diagonal; photographs of spinning triangle captured in modified system

With the help of a high speed camera system (OLYMPUS i-speed3), we are able to capture pictures of the spinning triangle in different diagonal paths (Fig. 2.).

Traditionally, the fibre tension distribution within spinning triangle was usually considered to be symmetric. However due to twist effect, the distribution of fibre tension within the triangle is asymmetrical and uneven in the practice of ring spinning. Conventionally in a Z-twist spinning process, fibre on the right side of the triangle always get twisted firstly. This is called to be a pre-twisting process in Xungai Wang's research [6, 7]. In Fig. 2(b), the effects of this pre-twisting process could be observed. In the conventional yarn path, due to the pre-twist effect, there seems to be a dislocation between left and right sided fibre which indicates fibres on different side are not twisted within a plane in the triangle. The left hand fibres are underneath the plane of the right side fibres. Moreover, the right side fibres which become the subject of the twisted yarn get better bounded up and controlled. It is the left side fibres that most long hairiness comes from.

With a left diagonal path, this pre-twist effect is reinforced even more, as shown in the Fig. 2(a). It intensifies the asymmetry of fibre tension distribution between the left and right side fibre. While a right diagonal path could ease the pre-twist effect, balance the fibre tension and fibre distribution on both sides, get each side fibres twisted on one plane, eventually create a much less asymmetrical spinning triangle leading to less long hairiness, as it is shown in Fig. 2(c).

3.2. The Effect of Diagonal Offset on Hairiness

The hairiness result of various left diagonal offsets showed there is no significant regular of offset's influence over hairiness since the best hairiness performance of each count of yarn appears on different left offset.

On the right diagonal circumstances, the best hairiness performance always showed up on the 12mm offset over every count of yarn. We believe there is a point existing beside 12mm offset where the spinning triangle gets the most balanced and symmetrical distribution of fibre tension. The maximum reduction of 3-9mm long hairiness from Ne 20, Ne 40 to Ne 60 was 42.6%, 28.5% and 21.3%, which means this modified system gets more significant result of improving yarn hairiness on coarser count of yarns.

4. Conclusion

There is no significant change in unevenness as well as tensile properties of both left and right diagonal yarns. The test results of all counts of yarns show the diagonal path and offsets influence the yarn hairiness mostly.

It is observed that diagonal path is the most important factor to decide yarn hairiness over all counts of yarns. The result of left and right diagonal yarns hairiness is quite different. Very few left diagonal yarn performs improvement of hairiness, while almost every right diagonal yarn reduced a great amount of 3-9mm long hairiness.On the right diagonal circumstances, the best hairiness performance always showed up on the 12mm offset over every count of yarn. The maximum reduction of 3-9mm hairiness from Ne 20, Ne 40 to Ne 60 was 42.6%, 28.5% and 21.3%, which means this modified system gets more significant result of improving yarn hairiness on coarser count of yarns.

Photographs of spinning triangle captured in modified system by high speed camera indicate that due to the pre-twisting process, the fibre tension distribution of spinning triangle is asymmetric on conventional yarn path. With a left diagonal yarn path, this pre-twisting effect is reinforced to create an even more asymmetric spinning triangle in a Z-twist condition. On the contrary, a modified right diagonal spinning path helps to make a more balanced and symmetric distribution of fibre tension within spinning triangle.

Acknowledgements

This paper is sponsored by the National Natural Science Foundation of P. R. China under Grant 11102072 and Science and Technology Agency of Xinjiang Uygur Autonomous Region (Technology Support Project in Xinjiang in 2011, 201191112).

Reference

[1] K. Fujino,, M. Uno, A. Shiomi, Y. Yanagawa, and Y. Kitada. A Study on the Twist Irregularity of Yarns Spun on the Ring Spinning Frame. The Textile Machinery Society of Japan, 8: 51-62, 1962.

[2]Y. V. Pavlov. Structural Transformations in the Fiber Assembly at the Twist Threshold at the Instant of Rupture. Technology of the textile industry, USSR 4: 57-63, 1965.

[3]W. Klein. Spinning Geometry and its Significance. International Textile Bulletin: Yarn Fabric Forming 139: 22-26, 1993.

[4]H. W. Krause, H. A. Soliman, and J. L. Tian. Investigation of the Strength of the Spinning Triangle in Ring Spinning. Melliand Textillberichte, 72: 499-502, 1991.

[5]N. S.Shaikhzadeh. An Analysis of the Twist Triangle in Ring Spinning. PhD Thesis, University of New South Wales, Australia, 1996.

[6]Wang Xungai, Chang Lingli. Reducing Yarn Hairiness with a Modified Yarn Path in Worsted Ring Spinning. 73(4): 327-332, 2003.

[7]Wang Xungai. Recent research on yarn hairiness testing and reduction: Part-Reduction of Yarn Hairiness. Research Journal of Textile and Apparel, 3(1): 1-8, 1998.

[8]G. Thilagavathi, D. Udayakumar, L. Sasikala. Yarn hairiness controlled by various left diagonal yarn path offsets by modified bottom roller flute blocks in ring spinning. Indian Journal of Fiber and Textile Research, 34: 328-332, 2009.

[9]Hua Tao, Tao Xiaoming, Cheng Kwok Po Stephen and Xu Bingang. Effects of Geometry of Ring Spinning Triangle on Yarn Torque Part I: Analysis of Fiber Tension Distribution. Textile Research Journal, 77(11): 853-863, 2007.

[10]Hua Tao, Tao Xiaoming, ect. Effects of Geometry of Ring Spinning Triangle on Yarn Torque: Part II: Distribution of Fiber Tension within a Yarn and Its Effects on Yarn Residual Torque. Textile Research Journal, 80(2): 116-123, 2010.